RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #16

Requirements for processing of overlapping sync triggers

Authors:
L. Bachman, JHU APL
E. Valovage, Sensis Inc.
T. Mosher, Garmin AT Inc.

SUMMARY

This Working Paper addresses an Action Item regarding whether the minimum requirements for the processing of sync trigger events are fully specified, with regard to the minimum rate at which overlapping sync triggers will occur in high density traffic scenarios.

Introduction

In RTCA/DO-282 subparagraph §2.2.8.3.3, the minimum requirements for processing ADS-B Sync Trigger events do not address the expected rate at which overlapping message events will occur (i.e. gives no guidance on the rate of occurrence of detectable overlapping messages).

The present test procedure (§2.4.8.3.3) presents without justification that detecting 100 overlapping messages per second is sufficient to validate the sync detection requirements.

This working paper is an attempt to determine whether the presently stated requirements are sufficient, and whether additional requirements and test procedures are necessary.

Analysis

Analysis by simulation was performed on the number of sync trigger events per second detected by a receiver at the center of the traffic scenario. See the attached Appendix for the full simulation results.

In summary, the worst-case mean rate for sync detection is 930 per second, for an A3 bottom antenna receiver at 40,000 feet in the LA2020 scenario. Note that there are about 3,000 total participants in LA2020, resulting in 930 sync detects, and yielding 700 successful messages per second (see MOPS Table 2-66 and Appendix K). With 3,000 participants sharing 3,200 message slots, this shows that while most of the transmitted messages experience an overlap, the majority of the overlaps are undetected. Therefore, the requirement for sync processing is only marginally higher (32%) than the rate of successful message reception (930 / 700 = 1.32). Of the 930 sync trigger events, 230 of them (~25%) do not result in a successful message reception.

Since there is presently no minimum requirement for the rate of processing of sync detections, it appears that an additional requirement would be beneficial.

Additional Discussion of "Embedded Sync" Detection

It is necessary to cope with the possibility that an "embedded sync" occurs in the payload of a message, as intended by the phrase in the requirement "…"regardless of other trigger activity subsequently detected." However it is not necessary to validate that requirement at the same processing rate as is required for overlapping sync detection, since the presence of the "embedded sync" is statistically unlikely. The test procedure of §2.4.8.3.3 is substantially over-testing this requirement.

Proposed Requirement

Add the following text as a new subparagraph 'd' to §2.2.8.3.3:

d. The decode process **shall** be able to process a minimum of 930 trigger events per second, with at least 115 trigger events that do not lead to successful message reception occurring in each of the overlap conditions described in subparagraphs b. and c. above.

Proposed Test Procedure

Revise the §2.4.8.3.3 test procedure as follows (instructions in ***bold italics***):

Replace the Equipment Required section with the following material:

Desired Message Signals:
Provide a method of supplying the UUT with four sources of desired Long ADS-B Messages. Each signal source generates messages according to a fixed schedule based on a 30 MSO modulus epoch, with specific additional time offsets for each source. There are a minimum of 117 transmission epochs per second. The data contents, transmission schedule, and offset times are:

Message Contents for All Message Sources:

- Payload Type Code = 1
- Address Qualifier = 0
- ICAO Address: (see below)
- For Message Source 1 only, Byte 25 bit 1 through Byte 29 bit 4 (36 bits) are filled with data corresponding to the ADS-B Synchronization Pattern. This is referred to as the "embedded sync" pattern.
- The remainder of the payload is filled with pseudo-random data, and valid FEC parity is provided.

Transmission Schedule and Offset Times for each Message Source:

Message Source	Tx Schedule (in MSOs relative to each epoch)	Additional Time Offset	ICAO Address
1	0, 10, 20	0 usec	0x000001
2	5, 15, 25	0 usec	0x000002
3	15, 25	150 usec	0x000003
4	25	300 usec	0x000004

Sources 1 and 2 each generate a minimum of 351 messages per second.
Source 3 generates a minimum of 234 messages per second.
Source 4 generates a minimum of 117 messages per second.
The first transmission epoch of each UAT frame (1pps interval) should be not later than absolute MSO 541.

Modify Step 1 as follows:
Message Source 1: -80 dBm
Message Source 2, 3, 4: off

Observe that the UUT equipment reports only reception of messages with ICAO address 0x000001 at a success rate of 90% or greater.

Delete the last half of the Note, starting from ", nor does it…".

Revise Step 2 as follows:
Message Source 1: -80 dBm
Message Source 2: -80 dBm
Message Source 3: -65 dBm
Message Source 4: -50 dBm

Observe that the UUT equipment reports receptions per the following table:

Item	Number per second
ICAO = 0x000001 Message Receptions	At least 90% of messages transmitted (351 nominal)
ICAO = 0x000002 Message Receptions	At least 90% of messages detected (117 nominal)
ICAO = 0x000003 Message Receptions	At least 90% of messages detected (117 nominal)
ICAO = 0x000004 Message Receptions	At least 90% of messages transmitted (117 nominal)
Sync Trigger Events	930 (minimum)

Delete Step 3

Appendix: Synchronization Triggering (courtesy JHU APL, thanks Larry and Mike)

LA2020

UAT air-air simulations were run for the LA 2020 air traffic scenario for three different receivers: an A3 receiver at 40,000 ft., an A0 receiver at 15,000 ft., and a receiver at a ground station. All receivers are located at the center of the scenario. No Link 16 interference was included in the simulation, but co-site interference was.

A count was kept of sync sequences that trigger the receiver decode process for each second of simulation. For each ADS-B Message incident at the antenna with a signal greater than –105 dBm, the probability of successfully decoding the initial 36-bit synchronization sequence was calculated. If the probability of correct synchronization sequence was greater than 0.5, the count was incremented.

Statistics were tabulated for each type of receiver as shown below in the table and figure.

Receiver		Min	Mean	St. Dev.	Max
A3 @ FL 400	top	825	867	17	927
	bottom	871	930	18	982
A0 @ FL 150		774	824	17	867
Ground		286	306	8	325

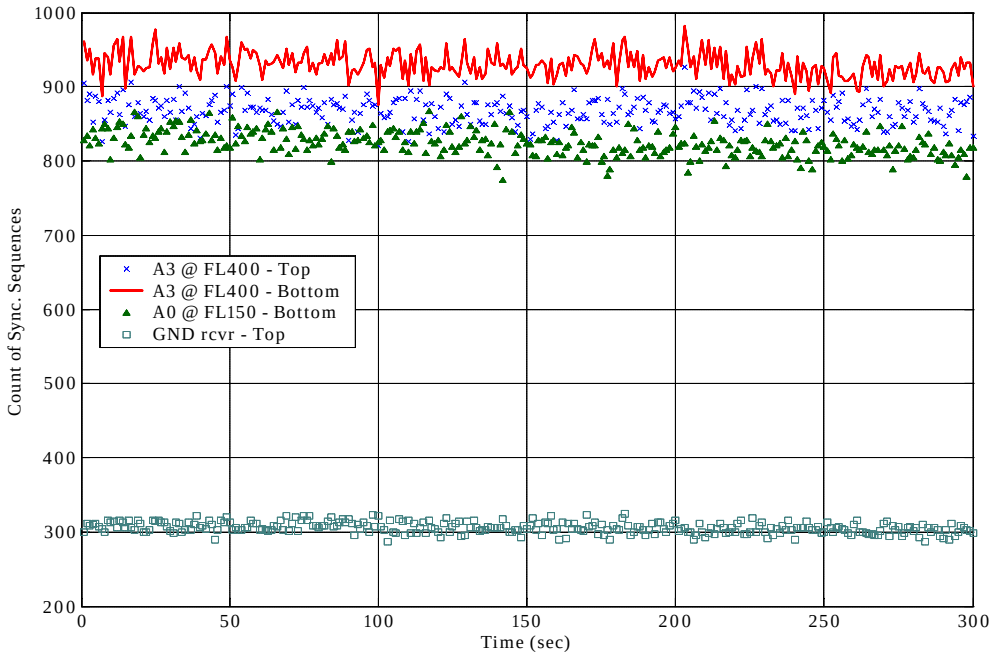

Figure 1 - Count of Sync. Sequences in Each Simulation Second for LA 2020 Scenario

CE2015

We did the CE2015 analysis of number of synchs, and, although most of the results were similar to, or less stressful than, LA2020, the following were different:

- The A0 at FL 150 has a max of 886, higher than 867 in LA.
- The ground station receives around twice as many synchs as in LA, probably due to the quite different altitude distribution of aircraft in CE.